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NEMATODE VECTORS - TRANSMISSION OF PLANT VIRUSES

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The first scientific evidence of the important role played by nematodes in vectoring and transmitting plant viruses was obtained in 1958, when Xiphinema index Thorne and Allen was found to be able to transmit the grapevine fanleaf virus from infected plants to healthy ones (7). This discovery opened a new field of research activity in plant nematology, and soon afterwards it was shown that certain groups of nematodes could transmit plant viruses to a wide range of plants.

Nematodes that transmit plant viruses occur in two families: Longidoridae, which comprise the three vector genera Longidorus, Paralongidorus, and Xiphinema, and Trichodoridae, comprising two genera, Trichodorus and Paratrichodorus. The longidorid nematodes vector polyhedral-shaped or isometric viruses called nepoviruses, while the trichodorid nematodes vector straight, tubular viruses called tobraviruses (5,11).

Longidorids are large nematodes, 2-12 mm (Longidorus, Paralongidorus) or 1.6-6 mm (Xiphinema) long in the adult stage. They possess an elongate, hollow spear which is used to penetrate cells in plant roots and feed on their contents. Trichodorus and Paratrichodorus are short nematodes and measure 0.5-1.5 mm in length. These nematodes possess a non-axial ventrally curved mural tooth or onchiostyle which is used to pierce epidermal cells of the root tip (11).

NEMATODE FEEDING BEHAVIOR: Longidorids feed at or above the root tip. Longidorus and Paratrichodorus species feed on the apical meristems of roots. This feeding results in hyperplasia and galling of the root tips and stunting of lateral roots. Xiphinema species feed at or behind the root tip and cause similar terminal and subterminal root swellings (Fig. 1). Root necrosis and discoloration of meristematic and cortical tissues are evident. The apical galls induced by these species are evidence that during the feeding process the nematodes discharge some substance into root meristems. These galls prevent root elongation of infected plants.

Trichodorid nematode feeding is restricted to the epidermal cells of the root (Fig. 2). This feeding causes root necrosis and root stunting which is descriptively termed "stubby-root" (3). The stubby-root condition may result from the injection of secretions by the nematode into the meristem.

VIRUS INGESTION AND VIRULIFEROUS ACTIVITY: Nematodes acquire viruses when they feed on virus infected plants. Xiphinema index can acquire grapevine fanleaf virus from infected plants in as short a time as a 5-15 minute feeding period (1,4). Up to a 24 hour feeding period may be required for other viruses.

Nematode vectors may acquire virus as soon as cell contents are ingested from infected roots, and there is no latent period within the nematode before transmission

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can occur. Some nematodes remain viruliferous for up to one year after acquiring the virus when the nematodes are stored at low temperatures without a host (2), however, many nematode vectors in the absence of virus infected plants, either lose the virus or lose the ability to transmit within the first few months (9). Nematode-transmitted viruses do not persist through nematode molt, nor pass through nematode eggs (6).

VIRUS TRANSMISSION AND RETENTION SITES: It is well known that viruses may be present in nematodes that are not vectors. In fact, the majority of plant-parasitic nematodes can ingest virus particles by feeding on virus infected plants. However, only the genera reported here are able to vector and transmit the ingested viruses to healthy plants. Vector species possess special retention sites in their bodies where the viruses are stored for a certain time and afterwards are released into the plant tissues during subsequent feeding periods. In species of Longidorus viruses are usually retained on the surface of the guiding sheath that surrounds the upper portion of the spear (odontostyle) (11) (Fig. 3). In species of Xiphinema virus particles occur in a monolayer on the lumen cuticular lining of the spear basal part (odontophore) and oesophagus, extending to the posterior end of the basal bulb (11) (Fig. 3). In Trichodorus and Paratrichodorus the particles occur about the pharyngeal wall and in the lining of the oesophageal lumen (11) (Fig. 3). The retention sites in Xiphinema and trichodorid nematodes are similar in their association with the oesophagus which are quite different from Longidorus.

During the process of virus transmission by nematodes, virus particles dissociate from the cuticular lining at the retention site and are carried by the nematode saliva into the host plant cells. Dissociation of the virus particles occurs when saliva, secreted by the oesophageal glands passes through the lumen of the oesophagus and adsorbs the virus particles at the site of retention. The particles are released in plant cells during initial phases of feeding (10). Successful transmission requires that infective virus particles are inoculated into cells that are not damaged.

The spread of a nematode transmitted virus from infected to healthy plants requires the following steps: i) virus multiplication in the host plant; ii) nematode feeding on the virus infected plant; iii) retention of the virus in the nematode's oesophagus after nematode feeding; iv) inoculation of a healthy plant by the viruliferous nematode and subsequent infection of the inoculated plant by the virus.

NEMATODE VECTORS AND PLANT VIRUSES: There are 22 longidorids (10 Longidorus, 1 Paralongidorus, 11 Xiphinema species) and 14 trichodorids (5 Trichodorus, 9 Paratrichodorus species) known to vector plant viruses (8). Of these viruses 14, 4, and 14 strains are transmitted by Longidorus, Paralongidorus and Xiphinema respectively. Five strains are transmitted by Paratrichodorus and 8 by Trichodorus (8).

In the longidorid group plant viruses such as tomato ringspot, tobacco ringspot, peach rosette mosaic, cherry leaf roll, cherry rasp leaf, arabis mosaic, grapevine fanleaf, tomato black ring and raspberry ring spot are transmitted by one or more of these nematode species. Plant viruses transmitted by one or both of the trichodorids are tobacco rattle and pea early browning viruses.

The damage inflicted by nematode vectors of viruses to plants is extremely serious because the detrimental effect of their infection is additive. Plants infected with these nematodes suffer from the depletion of nutrients and stunted roots as a

consequence of their feeding activity and are subsequently killed or impaired in their productivity by the deleterious effect of the virus infection that the nematodes induce.

Because the geographical distribution of both nematode groups is worldwide, and because they have a wide host range, nematode vectors of viruses have attracted a concentrated effort which has provided useful information on soil-borne diseases. In Florida trichodorid nematodes are important pests of potatoes because they transmit a virus (tobacco rattle) to potato. This virus causes a disease of potato tuber called "corky ring spot." Infected tubers become irregularly shaped during early stages of growth. The skin tissue cracks and brown concentric rings develop on the surface of the infected tuber. In late season, tubers exhibit deep cracks and shallow corky depressions on their surface which leaves them unmarketable.

CONTROL: The control of nematode vectors of plant viruses is extremely difficult and expensive because complete eradication of nematodes is necessary to prevent the spread of the virus infections. Even very low nematode residual densities remaining in the treated soil can spread the virus infection, nullifying the effect of the treatment. Long rotation periods (5-7 years) with non host plants have been effective in some cases.

LITERATURE CITED

1. Alfaro, A., and A. C. Goheen. 1974. Transmission of strains of grapevine fanleaf virus by Xiphinema index. Plant Disease Reporter 58:549-552.
2. Bergeson, G. B., K. L. Athow, F. A. Laviolette, and Sister M. Thomasine. 1964. Transmission, movement and vector relationships of tobacco ringspot virus in soybean. Phytopathology 54:723-728.
3. Christie, J. R., and V. G. Perry. 1951. A root disease of plants caused by a nematode of the genus Trichodorus. Science 113:491-493.
4. Das, S., and D. J. Raski. 1968. Vector efficiency of Xiphinema index in the transmission of grapevine fanleaf virus. Nematologica 14:55-62.
5. Harrison, B. D., J. T. Finch, A. J. Gibbs, M. Hollings, R. J. Shepherd, V. Valenta, and C. Wetter. 1971. Sixteen groups of plant viruses. Virology 45:356-363.
6. _____, and R. D. Winslow. 1961. Laboratory and field studies on the relation of arabis mosaic virus to its nematode vector Xiphinema diversicaudatum (Micoletzky). Annals of Applied Biology 49:621-633.
7. Hewitt, W. B., D. J. Raski, and A. C. Goheen. 1958. Nematode vector of soil-borne fanleaf virus of grapevine. Phytopathology 48:586-595.
8. Lamberti, F., and F. Roca. 1987. Present status of nematodes as vectors of plant viruses. Pp. 321-328 in J. A. Veech and D. W. Dickson, eds. Vistas on Nematology, Society of Nematologists, Inc. Hyattsville, MD.
9. McGuire, J. M. 1973. Retention of tobacco ringspot virus by Xiphinema americanum. Phytopathology 63:324-326.
10. Taylor, C. E. 1980. Nematodes. Pp. 375-416 in K. F. Harris and K. Maramorosch, eds. Vectors of Plant Pathogens. Academic Press, New York.
11. _____, and W. M. Robertson. 1975. Acquisition, retention and transmission of viruses by nematodes. Pp. 253-275 in F. Lamberti, C. W. Taylor and J. W. Seinhorst, eds. Nematode Vectors of Plant Viruses. NATO ASI., Ser. A: Life Sci. Vol. 2. Plenum Press, New York and London.

Fig. 1. Terminal and subterminal root swellings on two roots on left caused by *Xiphinema index* feeding on grapevine rootstock. Healthy root on right.

Fig. 2. *Trichodorus* sp. feeding at the root tip of a host plant. (Courtesy of R. P. Esser)

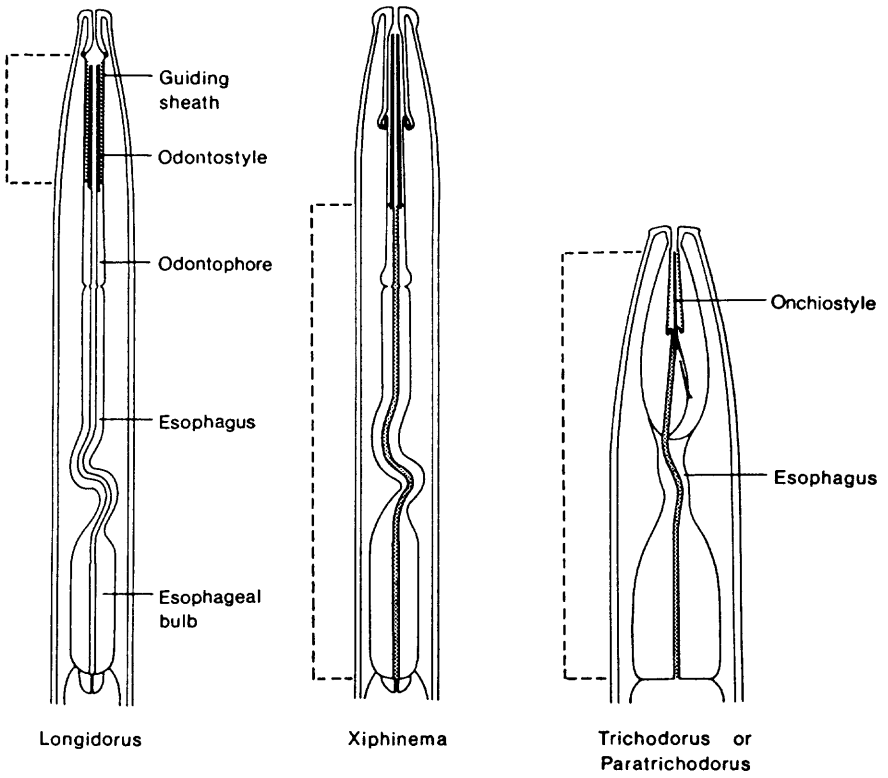

Fig. 3. Virus retention sites. Dotted lines illustrate the areas of virus retention by the Longidorid and Trichodorid nematode vectors. (C. E. Taylor and W. M. Robertson)

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